Palaeogeography, Palaeoclimatology, Palaeoecology 497 (2018) 201–217

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Cave deposits as a sedimentary trap for the Marine Isotope Stage 3 environmental record: The case study of Pod Hradem, Czech Republic

L. Nejman[a,g,*], L. Lisá[b], N. Doláková[c], I. Horáček[d], A. Bajer[e], J. Novák[f], D. Wright[g], M. Sullivan[a], R. Wood[h], R.H. Gargett[i], M. Pacher[j], S. Sázelová[k,l], M. Nývltová Fišáková[l], J. Rohovec[b], M. Králík[k]

[a] School of Philosophical and Historical Inquiry, University of Sydney, Australia
[b] Institute of Geology CAS, Rozvojová 269, Prague 6 165 00, Czech Republic
[c] Department of Geological Sciences, Faculty of Science, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic
[d] Department of Zoology, Faculty of Science, Charles University, Viničná 7, 128 43 Prague, Czech Republic
[e] Faculty of Forestry and Wood Technology, Mendel University, Zemědělská 3, Brno 613 00, Czech Republic
[f] Department of Botany, University of South Bohemia, Branišovská 31, České Budějovice 370 05, Czech Republic
[g] School of Archaeology and Anthropology, Australian National University, 14 Ellery Crescent, Canberra, ACT 0200, Australia
[h] Research School of Earth Sciences, Australian National University, 1 Mills Road, Canberra, ACT 0200, Australia
[i] Equinox Research and Consulting International Inc. (ERCI), 1229 Cleveland Avenue, Mount Vernon, Washington 98273, United States
[j] Institute of Palaeontology, University of Vienna and Biologische Station, Lunz am See, Austria
[k] Department of Anthropology, Faculty of Science, Masaryk University, Kotlářská 267, 611 37 Brno, Czech Republic
[l] Institute of Archaeology CAS in Brno, Čechyňská 19, Brno 602 00, Czech Republic

ARTICLE INFO

Keywords:
Palaeoclimate
Geoarchaeology
Human occupation
Micromorphology
Geochemistry

ABSTRACT

Pod Hradem Cave, located in the Moravian Karst, Czech Republic, offers an excellent opportunity for environmental reconstructions of Marine Isotope Stage 3 (MIS 3) in Central Europe due to its detailed sedimentary record dated 50,000 to 28,000 cal BP. Identifying the natural environments of the Middle to Upper Palaeolithic (MUP) transition is necessary to understand the settlement strategies and related behaviour of both Neanderthals and Anatomically Modern Humans, both of whom may have occupied the region at the same time. A multidisciplinary excavation was carried out between 2011 and 2016. Detailed analyses of the sediments, vertebrate microfauna, pollen and charcoal revealed minor but observable fluctuations in climate, with little change in the surrounding vegetation. The Pod Hradem palaeoenvironmental dataset is complex, but generally reflects a predominantly glacial climate with a range of vegetation types and habitats during the Late Pleistocene, followed by the warmer and more humid Holocene. The MUP transition as recorded in Pod Hradem Cave was a glacial environment interrupted by two relatively warmer periods. Central Europe experienced extreme climate fluctuations during MIS3, as recorded from different sedimentary archives, but it seems that the Pod Hradem Cave environment may have acted as a buffer zone, ameliorating those extremes, and providing a suitable refuge for both bears seeking winter hibernation dens and occasionally visiting humans.

1. Introduction

The extreme variability of Late Pleistocene climatic change in Europe is now widely acknowledged, and an increasing number of high-resolution climatic records demonstrate frequent high-amplitude climatic changes (Blockley et al., 2012; Moseley et al., 2014). During that time hominin populations in many different geoclimatic regions repeatedly experienced environmental shifts that sometimes occurred on decadal time scales (Allen et al., 1999; Bradtmöller et al., 2012; Clement and Peterson, 2008; van Andel and Davies, 2003). Rapid climate change during Marine Isotope Stage (MIS) 3 influenced the behaviour of Palaeolithic populations as evidenced by cultural changes and probably population breakdowns (Bradtmöller et al., 2012). Several studies examine the complexity of the Early Upper Palaeolithic (EUP) and Anatomically Modern Human (AMH) interaction in the Middle Danube region (Nerudová et al., 2016; Rougier et al., 2007; Svoboda et al., 2002; Trinkaus et al., 2003, 2013). The Danube Corridor and the Population Vacuum models for the early migration of modern humans into the Upper Danube Basin around 40 ka BP are linked to major climatic fluctuations around the time of Heinrich Event 4 cooling and so provide a framework for the geographic expansion of AMH into Europe (Conard and Bolus, 2003, 2008). When Europe was being

* Corresponding author at: 954 Oyster Creek Road, Rosedale, 4674, QLD, Australia.
E-mail address: lnej5536@uni.sydney.edu.au (L. Nejman).

https://doi.org/10.1016/j.palaeo.2018.02.020
Received 16 July 2017; Received in revised form 15 February 2018; Accepted 18 February 2018
Available online 23 February 2018

colonized by AMH, the impact of subsequent extreme climate changes caused other environmental conditions to switch repeatedly. A number of researchers discuss the adverse reaction of Neanderthal populations to climatic stress (e.g. El Zaatari et al., 2016; Jiménez-Espejo et al., 2007; Tzedakis et al., 2007; Stringer et al., 2003). Successful adaptation to abrupt environmental changes has been cited as a hallmark of AMH and was achieved through innovation in both technology and social organization, to create what Gamble (1999) described as 'a dispersal specialist with a global distribution'. The variability selection model proposes that as hominid evolution during the late Pleistocene era was increasingly dominated by great environmental instability, it resulted in hominids being exceptionally proficient in behavioural novelty, diversity and highly sophisticated use of environmental data (Potts, 1998). In general terms, the Neanderthals were also able to successfully adapt to many climatic changes during their long occupation of Europe and parts of Asia, however interpreting the evidence using the variability selection model, it appears that this characteristic may not have been as developed in Neanderthals as in AMH.

Identifying the palaeoenvironment at the time of the MUP (Middle to Upper Palaeolithic) transition is necessary to understand the settlement strategies and the behaviour of Neanderthals and AMH. Given the likelihood of early arrival of AMH in Moravia (Hoffecker, 2009; Richter et al., 2008) and the newly calculated ages for late Mousterian (e.g. Higham et al., 2014), it is plausible that both hominids may have occupied Moravia at the same time (also see Hublin, 2015). As Pod Hradem Cave provides a well stratified sedimentary archive for the period from 50,000 to 28,000 years ago, recording occasional human visits, the main questions of this study are as follows: (i) Can we reconstruct the palaeoenvironments in the cave surroundings from the sedimentary archive data and other proxy data?; (ii) Is it possible to reconstruct the climatic trends for the period of the MUP transition?; and (iii) Did humans visit the cave during specific climatic periods?

2. Climate and regional settings

2.1. Climate and environment of Middle Europe in MIS 3

The rapid episodic changes that took place during the MIS 3 period are well described on the global scale, but the regional patterns were complex and are less well understood. Terrestrial and marine proxies show that western European and offshore environments were affected strongly by Dansgaard–Oeschger (D–O) (Dansgaard et al., 1993) and Heinrich (H) events (Heinrich, 1988) that correlate roughly with the Greenland record. Greenland stadials were generally contemporaneous with semi-desert or steppe vegetation and Greenland interstadials with forests (see e.g., Sánchez-Goñi et al., 2002). Until recently, the effects of the D–O and H events on Central European biomes were virtually unknown; however, a recent study at the Hölloch cave has demonstrated that the climate of the high-elevation northern Alps was as responsive to D–O forcing mechanisms as Greenland (Moseley et al., 2014).

Vegetation communities changed frequently in response to those climate shifts, and are probably a detailed reflection of the regional scale of climatic changes, as for example in the case of Western, Central and Eastern Europe (Sirocko et al., 2016; Pirson et al., 2012; Allen et al., 1999; Feurdean et al., 2014). Although pollen analyses are available for short sections of sedimentary profiles in Moravia and adjacent regions (see Doláková, 2002; Jankovská, 2006; Jankovská and Pokorný, 2008; Rybníčková and Rybníček, 2014; Seitl et al., 1986; Svobodová, 1988), the lack of accurate dating prevents their integration into an overall scheme for local Late Pleistocene vegetation patterns. Therefore, the detailed Late Pleistocene climatic and environmental history of the central European region is not well known, especially the archaeologically significant period of the Middle to Upper Palaeolithic (MUP) transition, ca. 50–35 kyr (see e.g., Gamble, 1999; Svoboda et al., 2009; van Andel and Davies, 2003).

Broad climate trends for Europe during the period just before and during the MUP transition can be summarized as follows: a cold period occurred between 66 and 60 kyr near the end of MIS 4 when the Fennoscandinavian ice sheet spread south from northern Europe (van Andel and Davies, 2003). At the beginning of MIS 3, at about 57 ka (Lisiecki and Raymo, 2005) (compare with the suggestion of 59 ka in Pettitt and White, 2012), the ice withdrew rapidly and the climate remained moderately warm until it again began to deteriorate from about 44 ka (Barron et al., 2003). This deterioration continued to the end of MIS 3 (28 ka). With the onset of MIS 3, cold stadial events occurred more frequently until about 37 ka, after which the temperatures were as cold as, or even colder than the Last Glacial Maximum (LGM) (approximately 27 to 16 kyr) (see Davies and Gollop, 2003). The relatively short-term, millennial-scale D–O oscillations are difficult to correlate with archaeological events in practice because archaeological events are generally dated at a lower resolution than climatic events (van Andel and Davies, 2003), so the climatic oscillations during MIS 3 make any direct links between human behaviour and climatic conditions possible only at a general level (Barron et al., 2003).

Generalised climatic models are not applicable to individual sites or even regions. Europe is highly complex geographically and geomorphologically, so various microclimatic variables such as local topography and solar exposure need to be taken into account in any reconstruction (Blades, 1999). It is likely that Europe comprised a mosaic of different environments during this period. The relevance and validity of former local stratigraphic schemes also needs to be taken into account (Lisá et al., 2018; Vandenberghe and van der Plicht, 2016).

2.2. Caves as a possible environmental archive for MUP transition climate changes

Several different terrestrial sedimentary archives are available for palaeoenvironmental reconstructions of MIS 3 in Central Europe. The most widespread and much studied are loess deposits (Haesaerts et al., 2003; Sima et al., 2013), especially those associated with archaeological materials (Antoine et al., 2013; Fuchs et al., 2013; Lisá et al., 2014; Svoboda, 2009). The advantages of using the loess record derive from the near-continuous sedimentation across long distances allowing comparisons between sites, but the open conditions of loess formation means the loess record can provide only limited details.

Sedimentary deposits in caves provide another archive within which human as well as climatic impacts can be studied. Although cave sediments generally cannot provide palaeoenvironmental records with as much precision as marine or lacustrine deposits, partly because of hiatuses in deposition and inherent lack of dating precision, many such sites nevertheless act as sediment traps, and significant conclusions can be drawn from their sedimentary records (Karkanas and Goldberg, 2013; Woodward and Goldberg, 2001). The investigation of cave sites needs to be accompanied by detailed geomorphological, sedimentological, paleoecological and geochronological studies of the off-site Quaternary record (Woodward and Bailey, 2000).

Most of the environmental information for MIS 3 recorded in cave deposits has come from southern and western Europe (Courty and Vallverdu, 2001; Ellwood et al., 2001; Finlayson et al., 2006; Jennings et al., 2009; Karkanas and Kyparissi-Apostolika, 1999; Madella et al., 2002; Pirson et al., 2012; Walker et al., 2013; Zilhão et al., 2016). Collectively those deposits have provided information about the climate, which has varied from warm and humid through cooler and drier environments with different phases of hiatus or post-depositional change. On the other hand, only a handful of Central European caves have produced a detailed MIS 3 sedimentary record.

Important cave sites with long stratigraphic histories are found in the Ach (Brillenhöhle, Sirgenstein, Geissenklösterle, and Hohle Fels) and Lone Valleys (Bocksteinhöhle, Bockstein-Törle, Hohlenstein-Stadel, Hohlenstein-Bärenhöhle and Vogelherd) (Bolus, 2003) and in Bavaria (Hunas) (Rosendahl et al., 2011). The problem is that few of them have produced substantial data for detailed environmental interpretation.